i²MHB – a COST Action aiming multidisciplinary interoperability

J. Martins & R. Gonçalves

P. Tiano

UNINOVA and Faculty of Sciences and Technology, Universidade Nova de Lisboa, Lisbon, Portugal

CNR – ICVBC, Institute for the Conservation and Valorisation of Cultural Heritage, Toscany, Italy G. Bueno Fundación Santa María la Real, Aguilar del Campoo, Spain

A. Granic Faculty of Science, University of Split, Split, Crotia

C. Degrigny Château de Germolles, Mellecey, France

A. Lobovikov-Katz Faculty of Architecture and Town Planning, Technion - Israel Institute of Technology, Haifa, Israel

ABSTRACT: Nowadays, Heritage Buildings' areas of knowledge and applications have been developed without a global seamless integration view. Collaboration targeting the Heritage Buildings domain is actually focused on peer-to-peer partnerships, with a clear lack of integration and non-global interoperability. This imposes several constrains on Heritage Buildings, not only on scientific research but also on their daily operation. Today, the main challenge is to overcome these confined collaborations, moving towards a global integrated scientific, technological and social multidisciplinary approach. A fundamental pre-requisite for good decision-making about the future of Heritage Buildings is, first, knowledge and, then, knowledge sharing. The objective of i²MHB Action is to create a pan-European open network, to promote synergies between Heritage Conservators and Science's specialists, industrial stakeholders and research/education players, to achieve a unified common understanding and operation in the Heritage Buildings' domain, integrating multidisciplinary expertise, technology and know-how through a novel and independent global framework.

1! INTRODUCTION

Europe is one of the World's regions presenting the richest cultural heritage. Among this cultural heritage, Heritage Buildings (HBs) play a major role. In any initiative involving HBs a multidisciplinary approach is mandatory. HBs are undoubtedly an area where multidisciplinary is essential, being this multidisciplinary approach grounded on three major knowledge areas (pillars):

- •! scientific wisdom;
- •! systems and data;
- •! social engagement.

Europe's Framework Programs have supported more than 100 cultural heritage projects. Although many of them engage a multidisciplinary approach, mostly they present a limited scope and often each stakeholder (experts, professionals, curators, surveyors, architects, conservators, caretakers, end-users, stakeholders, general public, just to name a few) "speaks its own language". This "Babel tower" of vast knowledge is a major drawback to achieve a fully integrated and systematic approach that promotes cross-sectoral synergies leading to a greater understanding of which methodologies and technologies are best positioned to impact on HBs.

Nowadays, HBs' areas of knowledge and applications have been developed without a global seamless integration view. Collaboration targeting the HBs domain is actually focused on peer-to-peer partnerships, with a clear lack of global interoperability. This imposes several constrains on HBs, not only on scientific research but also on their daily operation.

Today, the main challenge is to overcome these confined collaborations, moving towards a global integrated scientific, technological and social multidisciplinary approach.

i²MHB (Innovation in Intelligent Management of Heritage Buildings) is a four-year COST Action, starting from 2015, aiming to create a Pan-European open network, to promote synergies between Heritage Science's specialists, industrial stakeholders and research/education players, to achieve a unified common understanding and operation in the HBs' domain, integrating multidisciplinary expertise, technology and know-how through a novel and independent global framework.

This common vision is extremely relevant and timeless, because now is the time to gather HBs' knowledge and technology (in its different pillars – scientific wisdom, systems and data, social engagement) and develop a common framework that will help users and stakeholders to push HBs to the next generation through global interoperation. HBs related research projects have been working on a confined peer-to-peer approach, whilst i²MHB Action is providing an inflection point in the HBs' field, enabling global common practices usage and triggering global scale innovation and seamless operation, independently of culture, place, technology and field of knowledge.

The impacts of the Action will support local authorities in their effort while establishing community identities and creating a sound sense of place.

2! RELATED WORK

In i²MHB Action, the aforementioned three pillars (major knowledge areas) will be the basis for a "rooftop" interoperability layer, as presented in Figure 1.

Action members will be engaged in a common interoperable framework of knowledge. The Action will identify what is homogenous, heterogeneous and synergetic amongst the three pillars, highlighting interdependencies and gaps while identifying best approaches in order to progress towards this common interoperable framework.



Figure 1. Action pillars.

Through its flagship initiative (Europeana) European Commission has invested a great deal of effort and resources to facilitate the access to and the reuse of cultural heritage data. In this view, Europeana uses linked data and semantic technologies. The Europeana Data Model structures and represents data delivered by various contributing cultural heritage institutions, builded upon established standards like RDFs, OAI-ORE, SKOS, CIDOC-CRM, Dublin Core. The Data Model acts as a common top-level ontology which retains original data models and information

perspectives while, as the same time, aims enabling interoperability. In the meantime, numerous efforts have been initiated which drive at combining linked data with other data sources in the context of digital stories. In the cultural heritage domain, Van Aart combined linked data from different sources and used location - aware mobile devices for searching and browsing a large number of cultural heritage information repositories (Van Aart, et al., 2010). However, despite the blooming research in the field, investigations disclosed that efforts to combine linked data and semantic technologies with storytelling, in the cultural heritage domain, are very few and still at an embryonic stage. Technological challenges coming from the linked data encompass: entity recognition, efficient and effective linking, URI and namespace management, data quality and reconciliation, federated querying and query expansion.

A wide range of research effort has been done concerning data collecting and data storage systems in HBs. Most of the research has been materialized through Europe's Framework Programs. Some of them relate HBs and climate protection (3ENCULT, 2014), while others develop and demonstrate, through case studies, a methodology for assessing and selecting energy efficiency interventions (Effesus, 2016). Among the most addressed research issues are the use of multi-sensors, wireless sensor networks and cloud computing procedures for data storage (Firesense, 2012), (Musecorr, 1012), (SMooHS, 2011), (SHBuildings, 2014). Most of the projects are either too much focused on basic research or confined on high-level cooperation without a global interoperability approach.

3! I²MHB OBJECTIVES

The objective of the i²MHB Action is thus to create a Pan-European open network through the Action's members network efforts and materialized in the form of:

- •! A common framework, which clearly defines:
 - o! Data collection and distilling (classification) of good and sound experiences related with preservation and rehabilitation of HBs. This implies the development of knowledge and data exchange between all Action members, having the main objective to assure the establishment of a common understanding regarding the complex problematic that must be solve in creating the HBs framework.
 - O! Development of common and adequate procedures in relation with the goal of the new framework. These correlated procedures will leverage the latent synergies between the different Action members. At the same time, these synergies will allow the coagulation of multi-criteria optimization procedures that should be included in the common framework.
 - ○! Development of a clear "back-processing" system, able to organic contribute at the enriching of know- how in the field of HBs preservation and their social and cultural valorization. The back- processing frame will allow not only the analysis and improving of data collections with good/bad examples, it also sources for new interoperability paradigms in development towards the creation of the common language. At the same time, this process will reveal better which is the impact on the full understanding of HBs rehabilitation and daily operation using the developed framework.
- •! The Action will produce a "white book" that will illustrate the synthesis of interoperability activities for improving the sustainability aspects related with HBs preservation. This white book will result from the collaboration with local, regional, countries and European authorities that will be attracted to actively participate. The aspects that will be tackled in this "white book" are very complex, because they will synthesize a large variety of aspects, from i) buildings energy efficiency, ii) zero-emission buildings, iii) preservation of sense and cultural role of HBs integrated into the urban and natural landscape and iv) evolution of HBs fund and its preservation at European level. In this sense, it will develop a roadmap of technologies suitable to be use in HBs rehabilitation and operation processes. An inventory register will be made regarding HBs' best practices related with i²MHB Action members' ongoing projects.
- •! A Public Report will be produced regarding "Integration of HBs into their surroundings", which will focus on study and optimization of HBs integration into the urban

and natural landscape. It will address preservation and valorization of specific HBs' characteristics and features in order to preserve the original facet and make it as much as possible realistic concerning ages, history and other related characteristics.

- •! A brochure will emphasize the social role played by HBs in leveraging the sociocultural dimension in different European countries. A large exchange of experiences, that will include contributions from local, regional and national authorities, will assure a better understanding of the message transmitted by HBs to society. The work at this brochure will be the result of a systematic approach made by conceiving, spreading, collecting, analyzing and synthesizing the results of questionnaires addressed to large target groups. This activity will provide a large database which, itself, will improve the framework.
- •! The Action will provide an open and extensible dissemination platform through which the new interactive, distributed and networked technologies deployed as mobile multifunctional devices will allow the extraction, exploration and collection of memories, actions and events. Managing actors can collaboratively pull apart and arrange memories, linking ideas, places, actions and events into meaningful historical stories, shaping and challenging individual understanding, comparing and contrasting their own individual stories. This platform will be available through the Action's web portal, which also works as a virtual network connecting all Action partners.

4! I²MHB ORGAZINATIONAL STRUCTURE

As i²MHB Action involves groups from different sectors, it achieves a "critical mass" to cover the whole range of expertise required to accomplish the Action's scientific and technological goals. This multidisciplinary empowers several distinct ways to set up the Action, each of them eventually producing distinct concepts based on the selection of priorities. An obvious choice would be to outline the Action with several Working Groups, each of them related with a particular area of expertise; however this wouldn't fit the Action goals of interoperability. Thus, the Action will be organized accordingly to its major outcomes, implying a strong interdisciplinary commitment between all players. One can state that the Action's Working Groups will act as a "transfer function" between the Action member's expertise and the Action's outcomes.

The Action is composed of 5 Working Groups (WG) interoperating and providing mutual feedback between themselves:

- •! WG 1: Common framework
- •! WG 2: Interoperability roadmap for Heritage Buildings' sustainability
- •! WG 3: Integration of Heritage Buildings into their surroundings
- •! WG 4: Social dimension of Heritage Buildings
- •! WG 5: Coordination and deployment.

Working Group 1 (Common framework) will be responsible for the establishment of the Heritage Buildings' Common Framework. This WG will consider several aspects raging from data collection and classification to the establishment of common procedures through the development of a clear processing system enabling the preservation of Heritage Building along with their social and cultural valorization.

Working Group 2 (Interoperability roadmap for Heritage Buildings' sustainability) will be responsible for the development of a roadmap of technologies and interoperability procedures that enhance the Heritage Buildings rehabilitation and daily operation.

Working Group 3 (Integration of Heritage Buildings into their surroundings) activities will be focus on the study and optimization of heritage buildings integration into their urban and natural landscape.

Working Group 4 (Social dimension of Heritage Buildings) will focus its activities on to the social role played by Heritage Buildings in the social landscape of different European countries.

Workgroup 5 (Coordination and deployment) will be formed with the task of taking care of coordination, outreach and dissemination, training activities, gender balance issues and involvement of young researchers. This WG will coordinate its actions with other groups' achieved outputs, being this coordination task of primordial importance.

5! WG'S ORGANIZATION

In order to better achieve its objectives, each WG is sub-divided in several tasks, with a respective leader and a defined number of collaborators. As an example, let us present the structure of the WG3 dealing with the Integration of Heritage Buildings into their surroundings.

It is divided into three working themes. The first one is related with the HBs perspective of the surroundings integration, the second one with the surroundings itself perspective and the last one combines the two previous perspectives. The tree working themes are then divided into several topics, as presented below:

- •! Theme "A" Heritage Buildings / Sites perspective
 - o! Topic A1: Optimized protection of HBs & sites
 - o! Topic A2: Conservation work on damaged parts of HBs
 - o! Topic A3: Replacement / reconstruction of missing parts on HBs
 - o! Topic A4: Re-use / retrofitting of HBs & sites
- •! Theme "B" Surroundings perspective
 - o! Topic B1: Legal protection of the surroundings
 - o! Topic B2: Modification / reshaping / functional change of surroundings
 - o! Topic B3: Highlighting of HBs
- •! Theme "C" Combined perspectives
 - o! Topic C1: Correlation between visual and technological characteristics
 - o! Topic C2: Documentation and monitoring of HBs & sites / surroundings
 - o! Topic C3: Technical training of agents involved in HBs and surrounding areas.

HBs might be historical or archaeological, of different periods, public or private, urban or in the countryside, listed or not. They might be or not located in an outstanding position, reachable, well maintained, physically protected, illuminated and exposed to natural aggressive environments (seaside, windy area) or human pollution (industries, electric cables, wind turbines). They can merge diverse combinations of values, and of material deterioration and structural problems. HBs can be fully authentic, partly or entirely restored. Innovative management of HBs aims at showing them in order that they give the visitors / local people a respectful vision of their condition state while providing useful information on their original appearance. In that sense the environment / surroundings and social appreciation are essential parameters to highlight the HBs.

The cross-relations among themes are presented in Figure 2. As an example legal surrounding issues are more related with optimized HBs protection and retrofitting rather than conservation or reconstruction of damaged/missing parts of HB.



Figure 2. WG3 cross-relations.

The organization of the different WGs pave the way to achieve the multidisciplinary "critical mass" to cover the whole range of expertise required to accomplish the Action's scientific and technological goals. This means that each WG is directly interconnected with all the others. No WG works alone but it cooperates in the global framework of the Action. Let us consider WG3 and WG4, which deals with the social role played by Heritage Buildings. It is easy to understand that there is a direct link between those two WGs, being the integration within the surroundings related with social aspects of that integration. Following there is a list of WG3 cross-topics with WG4:

- •! Impact of local agencies / politicians / owners on HBs / surroundings: legal protection of HBs / surroundings, issue of fund raisings
- •! Impact of local population / visitors on HBs / surroundings (SSY)
- •! Education (of society for protection of HBs and the importance of protection of their surroundings, as well (ALK))
- •! Involvement of local population in the management of HBs and events as well as the monitoring process (ALK) o Relation with tourists
- •! Feedback of local population / visitors (SSY)
- •! Innovation without education
- •! Innovation without respect of HBs / surroundings
- •! Innovation without authenticity.

6! I²MHB ACTION INSTRUMENTS

The Action objectives will be reached through a wide range of networking tools supported by COST, such as workshops, conferences, training schools, short-term scientific missions (STSMs) and dissemination activities. In particular, i²MBH has foreseen the following tools:

- •! Open Meetings (5)
- •! Think Tank Meetings (5)
- •! Early Career Investigator's Workshops (4)
- •! Training Schools (3)
- •! Industrial Days (2)
- •! Short Time Scientific Missions (several).

The first COST Action TD1406 training school, addressing Innovation in Intelligent Management of Heritage Buildings, took place in in Aguilar del Campo (Spain), from 27/01/2016 to 29/01/2016.

For three days, 26 students and researchers from Spain, Portugal, Croatia, Israel, Latvia, Lithuania, Malta, Slovenia and Italy have pooled experience and expertise in order to establish several lines of study and work (Fig. 3).



Figure 3. Training School attendees.

The headquarters of the Santa María la Real Historical Heritage Foundation (Fig. 4) has been the heart of this school of training, where different working areas have been studied, such as: 3D documentation of historic buildings; methodologies to counteract the effects of earthquakes on the assets; improving conservation and knowledge of heritage using drawing techniques (Fig. 5). The training school comprise also visits to places like the Monastery of Santa María la Real and the Romanesque chapel of Canduelapara, instrumented and monitored by the Monitoring Heritage System for an intelligent management and preventive conservation of cultural property (MHS, 2016).



Figure 4. Training School technical session.



Figure 5. Training School documentation session.

7! CONCLUSIONS AND REMARKS

The Action is now at its first year of activity and the structure of the working groups with preliminary activities have been set up. Several successful Short Time Scientific Missions have already been accomplished by Early Career Investigators fostering collaboration, sharing new techniques and infrastructures. Further Training Schools are foreseen along with Industrial Days. Particular focus will be given on industrial companies specialized in Heritage Buildings rehabilitation and maintenance, energy efficiency and technological integrators. More information about the Action can be found www.td1406.eu at or http://www.cost.eu/COST Actions/tdp/TD1406. It is foreseen that the Action will grown along with its developed work, and a further enhancement in human and technical means will assure that the Actions goals are achieved in accordance with the schedule.

ACKNOWLEDGMENTS

This article is based upon work from COST Action TD1406 i²MHB - Innovation in Intelligent Management of Heritage Buildings, supported by COST (European Cooperation in Science and Technology). Authors also would like to thank the financial support of Faculty of Sciences and Technology, Universidade Nova de Lisboa.

REFERENCES

3ENCULT. 2014. Efficient Energy for EU Cultural Heritage. Available at: http://www.3encult.eu.

- Effesus. 2016. Energy Efficiency for EU Historic Districts' Sustainability. Available at: http://www.effesus.eu.
- Firesense. 2012. Fire Detection and Management through a Multi-Sensor Network for the Protection of Cultural Heritage Areas from the Risk of Fire and Extreme Weather Conditions. Available at: http://www.firesense.eu.

MHS. 2016. Sistema de Monitorización del Patrimonio. Available at: http://www.mhsproject.com.

Musecorr. 2012. Protection of cultural heritage by real-time corrosion monitoring. Available at: http://www.musecorr.eu.

SHBuildings. 2014. Smart Heritage Buildings. Available at: http://www.shbuildings.eu.

SMooHS. 2011. Smart Monitoring of Historic Structures. Available at: http://www.smoohs.eu/tikiindex.php.

Van Aart, C. J., Wielinga B. & Van Hage, W. R. 2010. Mobile cultural heritage guide: location-aware semantic search. EKAW.